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Multimedia Transmission over IEEE 802.11g WLANs: Practical Issues and Considerations

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Abstract: **Multimedia transmission is widely available over wired networks. With the advent of low-cost WLAN devices, the wireless delivery of multimedia content is highly desirable. However, for media requiring low end-to-end latency, the use of WLAN technology introduces many significant challenges. These challenges are further enhanced if multicast/broadcast transmission is employed to serve a wide range of wireless terminals. This paper provides an understanding of the practical issues associated with WLAN multimedia transmission. A cross-layer measurement programme is performed to identify design issues for low-cost off-the-shelf WLAN multimedia systems. Problems identified include i) broadcast/multicast transmission using the slowest link-speed, ii) common link adaptation mechanisms for all clients, iii) lack of a call admission policy, and iv) irreducible PER even in good channel conditions.**

I. INTRODUCTION

There is growing interest in wireless multimedia delivery for the home and corporate (e.g. hotels and hospitals) environment. Wireless Local Area Network (WLAN) [1] extensions to existing wired infrastructure are growing rapidly, often in the form of hot-spots. The cost of WLAN equipment is falling fast and most portable terminals (laptops, PDAs and even cell phones) include a WLAN modem as standard. The use of WLAN technologies [2]-[3] for data communication is well established. Here the Transport Control Protocol (TCP) is used on top of the Internet Protocol (IP) to correct for missing or corrupted data packets. The transmission of video files via TCP-IP over WLAN allows the non-real-time playback of video files at the client. Near real-time video streaming via TCP-IP allows video playback without the need to store a local copy of the file. Since TCP cannot offer a time-bounded service, for low-latency video applications the video packets are sent using the User Datagram Protocol (UDP). While UDP offers a time bounded service, it does not guarantee the delivery of the video packets. To use this protocol successfully, the video codec must support strong error resilience and concealment. Furthermore, some video applications require transmission to a large number of remote terminals. Due to a lack of radio bandwidth, in these situations a dedicated point-to-point UDP-IP transmission cannot be accommodated with each remote client. Instead, Broadcast (or Multicast) transmission must be used at the WLAN. For these types of link there is absolutely no retransmission (ARQ) of errored or missing data packets (either at the WLAN MAC or the transport layer).

As discussed above, wireless UDP based unicast and multicast/broadcast transmissions pose the problem of packet erasures. The lossy nature of the transmission medium can lead to unacceptable video quality at the client. As a result, it is important to consider the channel behaviour in terms of packet delay, packet loss rate and data throughput. Moreover, for low-latency multimedia there are practical issues that can affect the performance and usability of the system. This paper illustrates these issues by analysing the cross-layer performance of a number of WLAN links. Observations are made after collecting and processing large sets of measurement data[1]. The paper provides an insight into the critical problems that arise in such scenarios and suggests a number of possible solutions.

II. PLATFORM AND MEASUREMENT DESCRIPTION

To collect measurement data, a platform consisting of a cross-layer enabled client/server software pair running on Windows XP-based laptops was developed [4]. This allows us to log and analyse a large range of parameters (across the transmission and protocol stacks) from the application layer to the physical (PHY) layer. The software enables us to characterise key issues that affect the radio performance, and that potentially degrade or prevent video delivery. The laptops use IEEE 802.11g Network Interface Cards (NICs), while the server is connected to a Belkin® IEEE 802.11g Access Point (AP) (*High-Speed Mode Wireless G Router*).

Three Unicast UDP links were configured at the AP with a load that increases over time. Using a fixed link-speed, each client makes the same requests to the server in terms of packet size and bit rate. This is illustrated in figure 1 for a target rate of 8 Mbits/s and a packet size of 300 and 1200 bytes. This example highlights the strong impact of packet length on the radio performance, and therefore its possible impact on video performance. The data shows (figure 1 - left) that with small packets lengths, the network can only support a single client at 8Mbits/s. When clients 2 and 3 join the network, thus increasing the load to 16 and 24Mbits/s respectively, the packet loss rate was seen to increase to 50% and 80% respectively. The target rate of 8Mbits/s cannot be maintained and drops to around 5Mbits/s and 1.8Mbits/s respectively for each client. We conclude that the network cannot support 3 links at such a high data rate when small packets are used for transmission.

III. KEY ISSUES

The following key issues have been identified:

i) Broadcast transmission: Figure 2 shows broadcast transmission for a packet size of 600 bytes and a target video rate of 700kbits/s and 1 Mbits/s. In broadcast, the WLAN can only support application data rates of 700kbits/s. Only a small amount of transmission error is seen at the lower rate. These errors can be considered insignificant when error resilient video codecs are used.

[1] This work was performed as part of the EU FP6 WCAM project

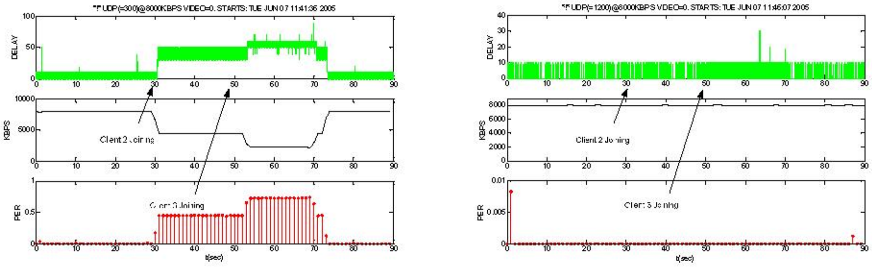

Figure 1: UDP Static Unicast - Channel behaviour - Video Bit Rate = 8Mbits/s , Packet Size = 300 bytes(left) 1200 bytes(right).

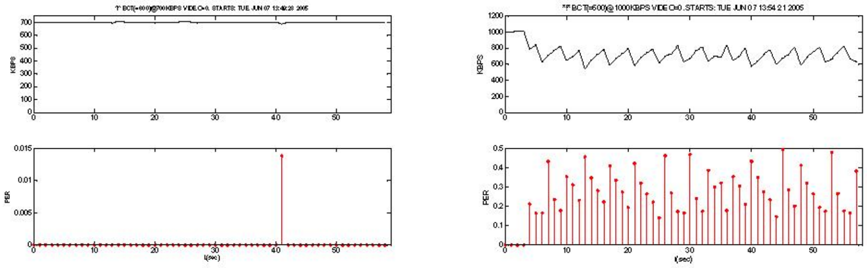

Figure 2: Broadcast Static- Channel behaviour - Packet Size = 600 bytes - Video Bit Rate = 700kbits/s (left), 1Mbits/s (right).

At 1Mbits/s the performance is unacceptable due to a lack of broadcast bandwidth at the AP. This occurs since the AP uses the lowest available link-speed (1 Mb/s) to optimise the broadcast coverage area. This severely limits the quality and quantity of broadcast video that can be sent from the AP.

ii) Near-Far problem 1: In this scenario a static client is positioned close to the AP, while a mobile client moves to the edge of the hot-spot. As the mobile client moves away from the AP, reception is seen to deteriorate. More surprisingly, the static client close to the AP starts to experience poor reception. This is explained by the fact that many low-cost APs uses a common link–speed on the downlink for all connected clients, and thus adapt their link-speed using an average of the packet statistics from all links. If one client experiences poor channel conditions then this will degrade the overall set of statistics. As a result, the AP reduces the link-speed for *all* associated clients. To overcome this problem it is necessary for the AP to implement link-adaptation on a 'per peer-station' basis. A set of statistics must be maintained at the AP for each peer-station (client). Link adaptation can then occur optimally for each client.

iii) Near-Far problem 2 (lack of "call admission"): In a similar scenario to that described above, the client far from the AP experiences poor channel conditions and thus adapts to the slowest, but most reliable, link-speed. UDP and TCP WLAN links make strong use of MAC level ARQ. Hence, given the poor channel conditions, the far client consumes considerable resource from the AP (since the link-speed is low and many packets must be resent). The far terminal effectively steals bandwidth from the high quality clients near to the AP. Packets intended for 'near' clients cannot be sent until the transmission cycle to the 'far' client is complete (which could require in excess of 30 retransmissions). One solution to overcome this 'bandwidth starvation' phenomenon is to implement a Call Admission policy that rejects users that require the use of the lowest link–speed. Alternatively, users that make excessive use of MAC layer ARQ could be rejected. This would ensure that only terminals with good channel conditions can communicate with the AP. Without this procedure, a single poor user will degrade the performance to all other users connected to the AP.

v) Irreducible PER: For all our WLAN UDP and broadcast/multicast measurements a residual application layer PER was observed. This occurred despite MAC level ARQ, and even for terminals in good channel conditions. These errors were related to 1) interference from other co-existing networks; this leads to congestion and collision, and 2) packet loss due to low battery levels and load fluctuations on the host laptop (operating system calls, anti-virus software, WLAN drivers and utilities). This residual PER is variable and was found to lie at around 0.5% to 2%.

IV. Conclusion

This paper has presented a number of practical issues that affect UDP and multicast/broadcast video transmission over WLANs. Observations were made after post-processing cross-layer data from a number of trials. Key issues from this study include i) multicast/broadcast transmission using the slowest mode, ii) common link adaptation mechanisms for all clients at the AP, iii) a lack of 'call admission', and iv) irreducible PER in good channel conditions.

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